5 ENERGY CONSUMPTION IN TRANSITIONAL ECONOMIES: JEVONS' PARADOX FOR ROMANIA, BULGARIA, HUNGARY, AND POLAND (PART I)

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Abstract

In this paper, we argue that improved energy efficiency leads to increased consumption of energy for the transitional economies of Romania, Bulgaria, Poland, and Hungary. The concept that energy consumption increases with improved energy efficiency is known as Jevons' Paradox. We will provide some evidence that Jevons' Paradox may exist for the four study countries and discuss why this result may be occurring. Analysis of this kind is vital because it could enable policy-makers to develop national energy strategies that would account for the stages of economic development that their countries reached. For two of these countries, Romania and Bulgaria, the results provided in the paper have strong policy implications as these countries must meet European Union standards as they are admitted into the community.

Keywords: Energy economics, Jevons' paradox, Transitional economies
JEL: O13, P28, Q4, N7

1. Introduction

The revolutions that spread throughout Eastern Europe (EE) in 1989 initiated, for those countries, a transitional period from a centrally planned economy towards a free-market economy. The years immediately following the fall of communism have brought high unemployment, hyperinflation, declining GDP, social dislocation, broken

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families, and falling life expectancies (Bromley, 2000). As such, the public policies were significantly altered to try to respond to these conditions, generally moving towards a free-market system. The energy sector, a vital component of any economy, was considerably reformed in the EE countries following the revolutions. Under communist rule, the emphasis was on developing the energy-intensive industrial sector, causing the use of energy per unit of output to be much higher than in the West (Gros and Steinherr, 2004). The focus on advancing the industrial sector led to several problems in the energy sector: according to Manser (1993, p.126) the inherited energy problems in transitional countries included, among others, subsidized prices, the lack of incentives and of mechanisms for energy conservation, and centralized control of electricity generation; all encouraging inefficient energy use. This concept, increasing energy efficiency to reduce energy consumption, has been debated for many years. Standard economic theory states that higher energy prices will stimulate research and development of new technologies that will reduce energy consumption. As Velthuijsen and Worrell (2002) found, as new technologies emerge the energy intensities of households and firms will decline in the long-run. However, will public policies promoting energy efficiency actually reduce energy consumption?

In this paper, we will argue that energy efficiency leads to increased consumption of energy. We will show that, on the macro level (country and multi-country), for the transitional economies of Romania, Bulgaria, Poland, and Hungary there is some evidence that Jevons' Paradox may exist. Analysis of this kind is vital because it could enable policy-makers to develop national energy strategies that would account for the stages of economic development that their countries reached. Section 2 presents a discussion of Jevons' paradox and examines the relevant literature on the subject. Section 3 describes the data and the various models that are used in the paper. Section 4 presents the results of the models. Section 5 discusses the implications of the findings and concludes the paper.

2. Jevons' Paradox

The argument known as 'Jevons' Paradox' concludes that increased demand for a resource due to efficiency will occur because of a rising level of possible production (Jevons 1865, 1965). Stanley Jevons' detailed this idea in *The Coal Question*, using the history of the steam engine to illustrate his point of how each efficiency improvement led to increases in the scale of production and in the demand for coal. Jevons wrote, "Every such improvement of the engine, when affected, does but accelerate anew the consumption of coal. Every branch of manufacture receives a fresh impulse – hand labor is still further replaced by mechanical labor" (Jevons 1865, 1965). Georgescu-Roegen (1975) found that improvements in technology tend to be energy-using and labor-saving, through the use of more powerful energy converters. In other words, efficiency leads to an implicit decrease in price and greater demand because the same budget constraint purchases a larger consumption bundle. Thus, the greater the efficiency improvements the greater demand will be.

There are numerous microscopic examples focusing on specific forms of energy consumption and/or activities to illustrate Jevons' paradox. Studies have examined the residential sector of individual countries (Haas and Biermeyr 2000; Milne and Boardman 2000; Berkhaut, Muskens, and Velthausen 2000; Roy 2000; Scott 1980), examined how industries consume energy when energy efficiency increases (Saunders 2000a; Jaccard and Battaille 2000), and have examined the determinants of energy use (Schipper et al. 2001). There are many contemporary examples as well. Even though the efficiency of food production per hectare has doubled, the number of people that are hungry has increased because of the swelling population (Giampietro 1994). New roads have not solved traffic congestion because they have encouraged the increased use of cars (Newman 1991). Traffic jams have further worsened by increased petroleum prices resulting in more energy-efficient automobiles, which has increased driving activity (Cherfas 1991). A final example would be refrigerators, where technological improvements have led to bigger refrigerators (Khazzoom 1987; Foster 2000).

Examples like those above are too numerous to list. However, the increase in demand for a resource is not strictly confined to a products' own end-use, but also for other end-uses because they compete for the same overall budget (Khazzoom 1980). Therefore, there is a direct micro rebound and an indirect macro rebound. In the case of a macro rebound, an income effect causes an increase in real income permitting the consumer to purchase an upgrade in quality, as well as an increase in demand (Wirl 1997, p. 20, 26-27, 31, 41, 197; Schipper and Grubb 2000; Saunders 2000b). There has been some evidence that technologically enhanced labor and capital results in more consumption per worker (Saunders 1992, 2000b; Alcott 2005). So, the macro level effects are economy-wide whereas micro level effects are specific to one product or sector. In the next section, we build upon these findings and describe the data and models that will be used to examine empirically if there is any suggestion that Jevons' paradox may exist for Romania, Bulgaria, Hungary, and Poland.

3. Description of Data and Models

A quick examination of the energy consumption statistics for the four countries under consideration in this paper might provide enough proof for some that Jevons' Paradox does not exist. However, these statistics can be misleading and a deeper macro-level analysis must be conducted. The energy consumption and efficiency conundrum can be thought of as analogous to the I=PAT equation developed by Ehrlich and Holdren (1971). One can consider energy consumption equal to environmental impact (I) and then examine how the three remaining types of macro factors influence consumption. These three types of macro factors are: (1) population size and population growth (P); (2) consumption variables such as gross domestic product, exports, imports, household consumption, government consumption, as well as all the growth rates of these variables which serve as a proxy for affluence (A); and (3) energy intensity which serves as a proxy for technological improvements (T) that increase efficiency. Therefore, the number of people, the level of consumption, and efficiency have a direct impact on the rate of deterioration of the environment, or in the case of this paper the amount of energy consumption. Using the analogy and the principles behind the I=PAT equation, the variables for the models presented in this paper were chosen.

Table 1 presents the mapping of the variables used for analysis in this paper to the I=PAT equation. Data for the period 1990-2004 was obtained from the Energy Information Administration's *International Energy Annual* 2005.

Table 1

Mapping of Variables to I = PAT Equation

Environmental Impact (I)	Population (P)	Affluence (A)	Technology (T)
Total Primary Energy Consumption	Population Density	Gross Domestic Product (GDP)	Energy Intensity
	Population	GDP per Capita	Energy Intensity per Capita
		Exports	
		Exports per Capita	
		Imports	
		Imports per Capita	
		Household Consumption	
		Household Consumption per Capita	
		Government Consumption	
		Government Consumption per Capita	

Total primary energy consumption measures energy usage in each of the countries examined. Population is used to determine if increases in the number of potential consumers are the major reason for increased energy use or not. Population density serves as a proxy for access to energy, as people living in an urban environment are more likely to have more access to energy than the rural populace. GDP and GDP per capita, in constant 2000 US $ and in purchasing power parity terms, are used as a measure of economic activity, which requires consumption of energy. The other affluence variables are used to dissolve GDP down to some of its components to determine which are most influential on total primary energy consumption. Exports, Exports per capita, Imports, and Imports per capita are used to illustrate openness to international trade and to serve as a proxy to determine if trading partners are taking advantage of these countries by exporting their production for energy intensive goods (i.e. the exports variables will have a positive coefficient). The Household and Government Consumption variables are used to determine which sector, the private or public, has the most influence on total primary energy consumption. For instance, are households purchasing products, such as electronics, now that they are flooding the market? Is the government undertaking infrastructure projects to prepare for entry into the European Union? These types of questions the Household and Government Consumption variables can answer. The Energy Intensity variables are used as a proxy for energy efficiency. Energy intensity illustrates how the intensity and components of energy use are changing in an economy.

The variables described above were chosen to capture as many macro-level effects that may be present as possible. Unfortunately, there is little, if any, work on national/regional levels on Jevons' Paradox. Furthermore, a macro-analysis will illustrate how a nation may have to respond to macroeconomic energy efficiency policies, such as those that the European Union is promoting. This distinction is significant because energy policies are becoming increasingly important and global. Each of these variables is used in the models described in the rest of the section.

Two types of regression analyses are conducted: time-series cross-sectional (TSCS) and generalized autoregressive conditional heteroskedasticity (GARCH(1,1)). TSCS regression models are used for analysis for the regional level. TSCS data eliminates heterogeneity and provides data that are more informative by eliminating the need for lengthy time series by utilizing the information available on the dynamic reactions of each subject (Kennedy 2003). TSCS data permits both spatial and temporal effects to be examined, allowing a subject to be studied over multiple sites and observed over a defined time frame; in this case energy consumption for four countries. Using time-series with cross-sections enhances the quality and quantity of data that would be impossible using only one of these two dimensions (Gujarati 2003).

Thus, TSCS is an invaluable tool. However, the regression estimates will likely be biased and inefficient. Several problems are frequent in TSCS analyses. First, errors tend to be serially correlated because observations and traits that characterize the error term tend to be interdependent across time. Second, the error terms tend to be correlated across countries. Third, heteroskedasticity is likely in TSCS data sets because the error variances tend not to be constant across countries. Fourth, the error terms may contain both spatial and temporal effects that produce a regression model with heteroskedastic and auto-correlated errors. The fifth and final problem that arises with TSCS analyses is that errors tend to reflect partial causal heterogeneity across time, space, or both (Hicks 1994). In addition to the problems listed above, correlation in the data set is expected. To correct for these problems, maximum likelihood estimators are calculated by iterating the Generalized Least Squares method to correct for group-wise heteroskedasticity and correlation across groups, as well as group specific autocorrelation. Furthermore, if, as expected, correlation is present in the variables chosen for this study, this technique provides unbiased estimators (Greene 2000). It is important to note that this technique does not produce a goodness-of-fit measure.

On the national level, ordinary least squares (OLS) models are used to analyze the data. However, in all cases presented in this paper, the Durbin-Watson statistics were less than the lower critical values at the 5% significance level indicating that first-order correlation was present among the disturbances. Therefore, a GARCH(1,1) model was used to analyze the time-series data. Time-series data allows for a sequence of observations to be examined to predict the future values of the variables. However, time-series data is likely to have heteroskedasticity and autocorrelation. The GARCH model, an alternative to standard time-series processes, was used to correct for these problems, imposing a special structure on heteroskedastic disturbances to obtain OLS best linear unbiased estimators (Murray 2006). Maximum likelihood estimation of the

GARCH model was used to determine if autocorrelation was present and to obtain estimators that are unbiased and error terms that are randomly distributed.

4. Results and Findings

As illustrated in Figure 1, Poland, Hungary, and Bulgaria each exhibit a small decrease in total primary energy consumption, and Romania had a rather large decrease over the period studied. Figure 2 shows the pattern of energy intensity for each of the four countries. As shown, each of the four countries has had a major decrease in energy intensity over the time-period studied, with Romania having the largest decline.

Figure 1

Total Primary Energy Consumption: 1990 - 2003

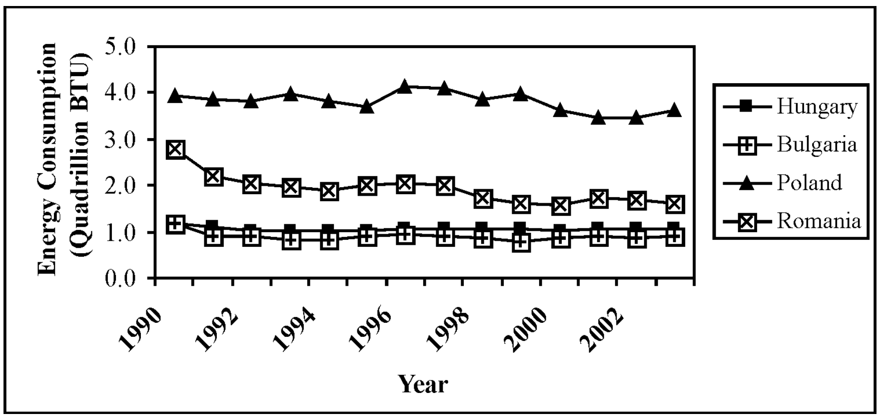
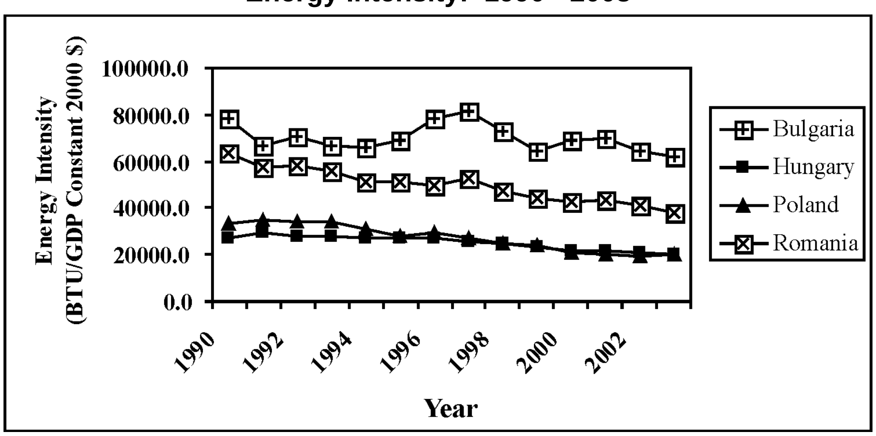


Figure 2

Energy Intensity: 1990 - 2003



A quick examination of the data would lead one to conclude that Jevons' Paradox does not exist for the four countries examined in this paper, as total **pr**imary energy consumption has decreased at the same time as energy intensity. However, further statistical analysis is needed to get a better understanding of which variables may affect total primary energy consumption the most. For instance, could Jevons' Paradox be in existence for the four countries even though energy consumption has decreased? This paper will examine if this is the case in Poland, Hungary, Bulgaria, and Romania, and if it is, it will make the case why using various macroeconomic variables that contribute to energy consumption.

One would expect that the energy intensity variable to have a positive coefficient if Jevons' Paradox exists. Moreover, given the I=PAT relationship, the coefficients for the population and GDP variables should be expected to be positive as well. Therefore, if there is a possibility that Jevons' Paradox exists in the study region and for each of the countries, the models in the following sections should produce results consistent with the analysis above.

4.1 TSCS Regional Results

The results of five regional TSCS models are presented in Table 2. Model 1 finds some evidence that Jevons' Paradox may exist in the study region. All three independent variables are significant and have positive coefficients signifying that as each of the variables increases, so does total primary energy consumption. The results indicate that energy intensity has the largest impact on total primary energy consumption; larger than the impact of both population and GDP (constant 2000 US $). Model 2 examined the same relationship as did Model 1, however GDP and energy intensity were measured in purchasing power parity (constant 2000 international $) instead of constant 2000 US $. The reason for using purchasing power parity is to equalize the exchange rates of the four countries to get a more accurate picture of their respective standards of living. The results show that there is little difference in the magnitudes of the coefficients of the independent variables between the models, except for the energy intensity variables which vary by a factor of ten for some cases.

Model 3 takes the analysis further, **breaking** GDP into **some of its components**, exports, imports, and government consumption to try to decipher which of the variables impact total final energy consumption the most. As the results indicate, there is evidence that Jevons' Paradox may exist, as the coefficient on the energy intensity variable is positive. However, an interesting result is that both exports and government consumption have negative coefficients, while the imports variable has a positive coefficient. These results may indicate that for the study region the countries are importing goods that are energy intensive; satisfying the needs of both households and the structural changes in their economies. Furthermore, the results may indicate that the goods countries are exporting or the governments are purchasing are not energy intensive. Of particular note is that household consumption was not significant in this model, indicating that the population in these countries has not been purchasing goods and services, or that just a small percentage of the population is able to afford these products. Additionally, these findings suggest that there may be a considerable amount of foreign direct investment in these countries to build industrial plants.

Table 2

TSCS Regional Regression Results

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	-0.1082	-0.3462	-0.1883	-1.9455	-3.2899
	0.069	0.0747	0.0675	0.2599	0.4094
	0.1173	0	0.005	0	0
Population	8E-08	6E-08	1E-07		
	(6E-09)	(6E-09)	(9.7E-09)		
	[0]	[0]	[0]		
Population Density (people per square kilometer)				0.0229	0.0303
				(0.0026)	(0.0042)
				[0]	[0]
GDP (constant 2000 $ US)	5E-12			2E-11	
	(1E-12)			(2E-12)	
	[0]			[0]	
GDP (constant 2000 $ International)		3E-12			
		(3E-13)			
		[0]			
Exports (constant 2000 $ US)			-8E-12		-9E-12
			(4E-12)		(3E-12)
			[0.0266]		[0.0118]
Imports (constant 2000 $ US)			1E-11		
			(3E-12)		
			[0.0005]		
Household Consumption (constant 2000 $ US)					4E-11
					(5E-12)
					[0]
Government Consumption (constant 2000 $ US)			-3E-11		-5E-11
			(1E-11)		(1E-11)
			[0.0023]		[0]
Energy Intensity	5E-06	0.00003	2E-06	0.00001	0.00003
	(6E-7)	(3E-6)	(5E-7)	(1E-6)	(2E-6)
	[0]	[0]	[0]	[0]	[0]
(Standard errors reported in parentheses)					
[p-values presented in brackets]					

Building upon these findings, Model 4 was changed slightly, using Population Density as an independent variable to determine if urbanization has an affect on total final energy consumption. As the results indicate, there is evidence that Jevons' Paradox may exist, and that population density has the largest impact on total primary energy consumption of any of the independent variables in the model. This result is likely to have occurred because there is more access to energy sources in an urban environment rather than a rural one. Furthermore, governmental regulations during the communist period restricted movement of citizens to cities. Model 5 extends the analysis further by examining the different components of GDP to determine which sector might have the greatest influence on energy consumption. Once again, the energy intensity variable has a positive coefficient indicating that Jevons' Paradox may exist. Similar to Model 4, population density has the largest impact on total primary energy consumption, signifying that urban regions have more access to energy sources than rural areas in the study region. Of particular note are the variables representing GDP's components. As in Model 3, both the government consumption and exports have negative coefficients, suggesting that those variables do not have a major impact on energy consumption. The likely reason for this result is that each of the countries undertook drastic measures, at the behest of the World Bank and International Monetary Fund, to reduce government spending in order to decrease their deficits. Unlike Model 3, the Imports variable was not significant; however, Household consumption was significant and had a positive coefficient. Building upon the analysis in Model 3, this result indicates that consumption of goods and services has been confined mostly to those living in the urban regions and the rural populace has yet to partake in the increase in consumption. This result is most likely due to the income inequality gap between urban and rural dwellers in the study countries.

4.2 GARCH Individual Country Results

The results of the five models suggest that Jevons' Paradox may exist in the four countries studied. However, a deeper analysis is needed on an individual country basis to confirm these findings. The following section will describe the results of the GARCH analysis used to perform the individual country analyses. As each of the study countries have gone through different structural changes in their respective economies, o**nly the models with significan**t results for each of the countries are presented.

Hungary

Four models, shown in Table 3, provided significant results for Hungary. In all the models presented, the first-order autoregressive parameter ρ (Rho) for the regression was significant at the 95% confidence level, indicating that the GARCH model fits the data significantly better than the corresponding OLS model because of autocorrelation. As all of the GARCH model results indicate, Jevons' Paradox appears to exist for Hungary, as all of the coefficients for the energy intensity variable were positive. An interesting finding is that the energy intensity variables had the largest impact on total final energy consumption except for Model 3 where population density has the greatest impact. This result indicates that access to energy sources is easier for urban dwellers than there rural counterparts. The result could also mean that most heavy energy intensive production occurs in urban settings. Another interesting finding was that the models with the exports, imports, household consumption, and government consumption were not significant. This finding suggests that no one component of GDP has a substantial impact on energy consumption in Hungary, although the aggregated GDP does have a positive influence.

Table 3.

GARCH Results for Hungary

Variable	Model 1	Model 2	Model 3	Model 4
Constant	-4.7297	-1.0692	-4.1973	-1.0692
	(1.0307)	(0.2325)	(1.212)	(0.2325)
	[0]	[0]	[0.0005]	[0]
Population	0.0000004			
	(1E-07)			
	[0.0003]			
Population Density (people per square kilometer)			0.0286	
			(0.0109)	
			[0.0089]	
GDP (constant 2000 $ US)	2E-11		2E-11	
	(2E-12)		(2E-12)	
	[0]		[0]	
GDP (constant 2000 $ International)		9E-12		9E-12
		(9E-13)		(9E-13)
		[0]		[0]
Energy Intensity (constant 2000 $ US)	0.00004		0.00004	
	(3E-6)		(4E-6)	
	[0]		[0]	
Energy Intensity per Capita (constant 2000 $ International)		0.0001		0.0001
		(0.00001)		(0.00001)
		[0]		[0]
Rho	0.8315	0.8937	0.7786	0.8938
	(0.1541)	(0.1244)	(0.174)	(0.1244)
	[0]	[0]	[0]	[0]
(Standard errors reported in parentheses)				
[p-values presented in brackets]				

Poland

Table 4 presents the results of six models that provided significant results for Poland. In Model 5, ρ was significant at the 95% confidence level, demonstrating that the GARCH model is a better fit due to autocorrelation. However, in the other models presented there was no significant difference in the fit of the OLS model to the GARCH model.

Table 4

GARCH Results for Poland

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	-16.7741	-13.4291	-14.091	-12.981	-64.939	-57.482
	(4.2942)	(4.828)	(3.6251)	(3.7387)	(8.9273)	(14.7473)
	[0.0001]	[0.0054]	[0.0001]	[0.0005]	[0]	[0.0001]
Population	3E-07	3E-07			2E-06	
	(1E-7)	(1E-7)			(2E-7)	
	[0.0022]	[0.0407]			[0]	
Population Density (people per square kilometer)			0.0811	0.0733		0.4276
			(0.0279)	(0.0288)		(0.107)
			[0.0037]	[0.0111]		[0.0001]
GDP (constant 2000 $ US)	3E-11		3E-11			
	(4E-12)		(4E-12)			
	[0]		[0]			
GDP (constant 2000 $ International)		1E-11		1E-11		
		(2E-12)		(1E-12)		
		[0]		[0]		
Exports (constant 2000 $ US)					8E-11	9E-11
					(1E-11)	(3E-11)
					[0]	[0.0021]
Imports (constant 2000 $ US)					-6E-11	-8E-11
					(1E-10)	(3E-11)
					[0.0004]	[0.0123]
Household Consumption (constant 2000 $ US)					8E-11	1E-10
					(2E-11)	(3E-11)
					[0.0001]	[0.0025]
Government Consumption (constant 2000 $ US)					-2E-10	-2E-10
					(4E-11)	(7E-11)
					[0]	[0.0008]
Energy Intensity (constant 2000 $ US)	0.0001		0.0001		0.0001	0.0002
	(2E-5)		(1E-5)		(1E-5)	(3E-5)
	[0]		[0]		[0]	[0]

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Energy Intensity per Capita (constant 2000 $ international)		0.0003		0.0003		
		(4E-5)		(4E-5)		
		[0]		[0]		
Rho	0.3583	0.4541	0.4332	0.4006	-0.7773	-0.2445
	(0.2589)	(0.2471)	(0.2499)	(0.2541)	(0.1744)	(0.2689)
	[0.1664]	[0.0661]	[0.0831]	[0.115]	[0]	[0.3631]
(Standard errors reported in parentheses)						
[p-values presented in brackets]						

Additionally, in all the models the energy intensity variables had positive coefficients suggesting that Jevons' Paradox may exist for Poland. In Models 1, 2, and 3, energy intensity or energy intensity per capita had the largest impact on total primary energy consumption, strongly implying that energy efficiency gains do not have the effect that policy-makers suggest they will. Of particular interest are Models 4, 5, and 6, which contain the population density variable. In each case, population density had the greatest influence on total primary energy consumption, suggesting that there may be a major divide among the urban and rural populace for access to energy sources and/or that, heavy energy-consuming industries are located only in the urban environment. In Mode**ls 5 and 6, GDP was broken down** into exports, imports, household consumption and government consumption. An interesting finding was that as imports and government consumption increase, total final energy consumption decreases. This result suggests that Poland is importing energy efficient products, while they are exporting energy intensive goods. Furthermore, the result indicates that the Polish government is not undertaking heavy infrastructure projects, rather focusing on less energy intensive projects. Also of note is the magnitude of the coefficient for population density in Model 6, which is very large in comparison to the other coefficients further supporting our claim that there is an inequality for access between the urban and rural dwellers and/or heavy energy consuming industries are located in the cities of Poland.

Bulgaria

Table 5 presents the results of six models that provided significant results of the GARCH analysis for Bulgaria. Models 2, 4, and 5 had a ρ that was significant at the 95% confidence level, demonstrating that the GARCH model is a better fit due to autocorrelation, while Models 1 and 3 had no significant difference from the OLS results.

All the models indicate that Jevons' Paradox may exist for Bulgaria, as indicated by the positive coefficient for the energy intensity variables. A result of particular interest is that on a per capita level, GDP has a greater impact on total primary energy consumption than energy intensity per capita. However, GDP has less of an impact than energy intensity. These results indicate that the wealthier Bulgarians are able to afford and consume energy and energy intensive goods more than poorer Bulgarians, suggesting a substantial income inequality gap, which has widened substantially during the 1990s as Bulgaria transitioned towards free-market operations. The other major findings for Bulgaria occurred in Model 3.

Table 5

GARCH Results for Bulgaria

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	-0.9807	-0.8604	-0.4019	-0.9731	-0.9862	-0.3559
	(0.0488)	(0.0434)	(0.8709)	(0.1373)	(0.1377)	(0.0921)
	[0]	[0]	[0]	[0]	[0]	[0.0001]
GDP (constant 2000 $ US)	7E-11					
	(2E-12)					
	[0]					
GDP per Capita (constant 2000 $ US)				0.0006		
				(6E-5)		
				[0]		
GDP (constant 2000 $ International)		2E-11				
		(4E-13)				
		[0]				
GDP per Capita (constant 2000 $ International)					0.0002	
					(1E-5)	
					[0]	
Exports (constant 2000 $ US)			5E-11			
			(2E-11)			
			[0.0025]			
Imports (constant 2000 $ US)			-4E-11			
			(1E-11)			
			[0.0084]			
Household Consumption (constant 2000 $ US)			7E-11			
			(8E-12)			
			[0]			
Household Consumption per Capita (constant 2000 $ US)						0.0005
						(4E-5)
						[0]

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Energy Intensity (constant 2000 $ US)	0.00001		0.000008			
	(4E-7)		(1E-6)			
	[0]		[0]			
Energy Intensity per Capita (constant 2000 $ US)				0.00001		0.00001
				(8E-7)		(1E-6)
				[0]		[0]
Energy Intensity per Capita (constant 2000 $ International)					0.00005	
					(3E-6)	
					[0]	
Energy Intensity (constant 2000 $ International)		0.00005				
		(1E-6)				
		[0]				
Rho	0.4217	-0.6222	-0.1718	0.9682	0.9564	0.4002
	(0.2514)	(0.2171)	(0.2732)	(0.0694)	(0.0809)	(0.2773)
	[0.0935]	[0.0042]	[0.5294]	[0]	[0]	[0.9885]
(Standard errors reported in parentheses)						
[p-values presented in brackets]						

The results for this model indicate that imports contribute to a decrease in energy consumption for the country. This finding suggests that the goods that Bulgaria is importing tend to be less energy intensive, which is further supported by the positive coefficient on the exports variable, which suggests that Bulgaria is producing energy intensive goods and selling them abroad.

Romania

Four models, presented in Table 6, produced significant results at the 95% confidence level for Romania.

Table 6.

GARCH Results for Romania

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	-2.2428 (0.1182) [0]	-2.2223 (0.1283) [0]	-2.287 (0.3357) [0]	-7.119 (2.1405) [0.0009]	-6.9886 (2.1122) [0.0009]
Population				2.E-07 (9E-8) [0.0201]	
Population Density (people					0.0511

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
per square kilometer)					(0.0222) [0.0218]
GDP (constant 2000 $ US)	5E-11 (3E-12) [0]				
GDP (constant 2000 $ International)		1E-11 (7E-13) [0]			
Household Consumption (constant 2000 $ US)			5E-11 (7E-12) [0]	6E-11 (7E-12) [0]	6E-11 (7E-12) [0]
Energy Intensity (constant 2000 $ US)	0.00004 (1E-6) [0]		0.00005 (3E-6) [0]	0.00004 (5E-6) [0]	0.00004 (5E-6) [0]
Energy Intensity per Capita (constant 2000 $ International)		0.0002 (5E-6) [0]			
Rho	0.6307 (0.2152) [0.0034]	0.6393 (0.2133) [0.0027]	0.1885 (0.2723) [0.4889]	0.4408 (0.2489) [0.0766]	0.4385 (0.2493) [0.0785]
(Standard errors reported in parentheses) [p-values presented in brackets]					

All of the models had a first-order autoregressive parameter ρ for the regression was significant at the 95% confidence level, indicating that the GARCH model fits the data significantly better than the corresponding OLS models. Additionally, all of the models had an energy intensity variable that had a positive coefficient, suggesting that Jevons' Paradox may exist for Romania. In fact, except for Model 4 the magnitude of the coefficient for energy intensity indicate that technological improvements have the greatest impact on total primary energy consumption. However, in Model 4, the population density variable had the largest impact on energy consumption, indicating that the majority of economic activity that is energy intensive occurs in cities, and that urban dwellers may have greater access to energy sources than the rural residents.

5. Conclusion

Jevons' Paradox is of prime importance, especially considering the current energy conditions that exist. People around the world have to contend with pollution and occasional energy blackouts when energy demand increases. Furthermore, energy prices are on a steady increase as the supply of natural resources that are used for energy production decrease. However, policy-makers, scientists, economists, and many others claim that new technological advancements will ease or solve any energy troubles that may arise.

The belief that technology is a solution has lead to public-policy that promotes this idea. For example, the European Union has developed policy that all members must aim at achieving an energy savings of 9% by 2012 through energy efficiency measures, and have created initiatives like the ManagEnergy Initiative and the Sustainable Energy Europe Campaign 2005-2008 (European Commission, 2007). Furthermore, new EU members are expected to reduce their energy intensity and energy consumption levels to those consistent with other member states.

However, this paper has presented the results of both regional and country-specific models for Poland, Bulgaria, Hungary, and Romania that provide empirical analysis that Jevons' Paradox may be in existence for these countries at the macro-level. This finding is significant given that energy consumption and energy intensity have decreased for each of the countries from 1990-2003. Therefore, one can conclude that policies promoting energy efficiency will likely not reduce energy consumption in these countries. However, why Jevons' Paradox may be in existence in these countries is of prime importance. The regression results indicate that the urbanization of the population and the liberation of the economic markets are the reasons why Jevons' Paradox may exist. The growth rate of population for each of the countries is either negative or stagnant, suggesting that there is significant migration from the rural regions to the urban centers. This hypothesis is supported by the positive coefficients for population density in the regression results presented. Therefore, these are the likely macro level reasons for the possible existence of Jevons' Paradox even if energy consumption and energy intensity has decreased over the study period.

The micro details as to why the results suggest that Jevons' Paradox exists for the region and these countries were not discussed here because such an examination of the evolution of the structure of the regional and individual economies and societies would require a deep investigation of each of the study countries. Further research will attempt to answer these questions to fully comprehend the micro reasons for the possible existence of Jevons' paradox. Moreover, the annual changes of each of the variables will be examined to determine if energy efficiency may be reducing energy consumption on a yearly basis. Such analyses will provide further support for the hypothesis outlined above as to the macroscopic existence of Jevons' Paradox. As each of the countries and the region continues to go through the stages of economic development, their energy consumption will continue to alter. Therefore, only through further study, can one understand the real reasons for the potential existence of Jevons' paradox; however, this paper does make an important contribution to its understanding. The second paper in the series will examine some of the structural differences in each of the countries studied by exploring energy intensity at a micro-level for different sectors of their economies.

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